VIRTUAL POWER SUPPLY CONTROL ENVIRONMENT FOR THE TPS PROJECT

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Abstract

The Taiwan Photon Source (TPS) is the latest generation of 3 GeV synchrotron light source which has been under construction since 2010. The control system infrastructure of TPS project is based upon the EPICS framework. In order to develop the control applications before power supplies of magnets delivered, it is necessary to set up the virtual control environment to develop high level application programs for the power supplies of magnets in advance. The high level application programs include operation process, degauss process and etc. for power supplies of magnet. The soft-IOCs (Input Output Controller) and various database records are needed to be built to simulate the power supply control environment. In addition, the operation interfaces of power supply will be designed and integrated according to location properties. The efforts will be summarized at this report.

INTRODUCTION

The TPS [1] is a latest generation of high brightness synchrotron light source which has been under construction at the National Synchrotron Radiation Research Center (NSRRC) in Taiwan since 2010. It consists of a 150 MeV electron Linac, a 3 GeV booster synchrotron, and a 3 GeV storage ring.

The EPICS (Experimental Physics and Industrial Control System) is a set of open source software tools, libraries and applications developed collaboratively and used to create distributed soft real-time control systems for scientific instruments such as the particle accelerators, telescopes and other large scientific experiments [2]. In the field of accelerators, many facilities have good practical experiences for the EPICS and adopt it as the accelerator control systems. Many resources and supports are available as well as numerous applications for accelerator have been developed.

As a result, the EPICS framework was also selected as control system infrastructure for the TPS project. The EPICS platform has been gradually built and tested to control and monitor the subsystems of the TPS. The various database records can be created for accessing the I/O data and setting parameters at the IOC (Input Output Controller) layer. Utilizing the EPICS channel access mechanism with the specific toolkits, the data can be accessed between the IOCs and the clients.

Before the magnets power supplies delivered, the virtual power supply control environment was constantly established for developing the operation applications in advance. The operation applications include the operation interface, power on/off setting and checking, degauss process and etc. The various operation processes will be developed and tested according to the various operation modes. The setup of building the virtual power supply control environment is introduced as followings.

POWER SUPPLY FOR TPS STORAGE RING

The TPS power supplies control interfaces are divided into four categories rather than a unified solution. These four kinds of power supplies will be provided by three different vendors. The reason of this choice is to meet the practical situation from manpower, budget and available vendors.

The storage ring dipole DC power supply will be equipped with Ethernet interface. Control resolution will be 18 bits effective number, noise and drift will be better than 10 ppm and it had contracted to IE Power [3] (acquired by Eaton Corporation in 2011). The intermediate power supply for storage ring quadrupole and sextupole with current rating 250 Amp will be equipped with Ethernet interface as well. The quadrupole power supply is 18bit with higher stability than sextupole with 16 bits. The two kinds of power supplies are both contracted to a local company Chroma ATE Inc. [4] and would have internal data buffer for post-mortem capability. Output current of the power supplies will output at rear plane BNC connector, which can connect to the cPCI ADC module for diagnostic purpose.

The small power supply for corrector magnets in the range of ±10 Amp categories will be interfaced to analogue interface directly. The power supply is NSRRC home made and manufactured by Industrial Technology Research Institute [5]. The controller interface CPSC (Corrector Power Supply Controller) is dedicated to be designed for both EPICS control system and fast orbit feedback application. Table 1 summarizes the specifications of these four power supplies.

Table 1: TPS Storage Ring Power Supply Summary

Applied SR Magnet	Mode	Max Current	Stability	Vendor	Control Interface
Dipole	Unipolar	750 A	±10 ppm	IE Power	Ethernet
Quadrupole	Unipolar	250 A	±2.5 mA	Chroma ATE Inc.	Ethernet
Sextupole	Unipolar	250 A	±12.5 mA	Chroma ATE Inc.	Ethernet
Corrector	Bipolar	± 10 A	±100 uA	Industrial Technology Research Institute	Analogue Interface

STORAGE RING POWER SUPPLY CONTROL

Control system for the TPS is based upon EPICS toolkit framework. The EPICS toolkit provides standard tools for display creation, archiving, alarm handling and etc. These toolkits which have various functionalities will be employed to monitor and to control accelerator system.

At each cell, controls of dipole, quadrupole and sextupole power supplies with Ethernet interface will be implemented on one cPCI IOCs crate running EPICS as Fig. 1. The cPCI EPICS IOC equipped with the latest generation CPU board will be standardized as ADLINK cPCI-6510 CPU module [6]. The 6U cPCI platform was chosen for the EPICS IOC platform. Local company manufactured crate and CPU module that could provide an economic solution is the major reason. The StreamDevice is a feasible module to build connection between EPICS IOC and power supplies.

Fig. 2 shows the small power supplies applied for both slow and fast correctors and skew quadrupoles. There will be 8 power supply modules in one crate and the most left slot will be plugged in one CPSC (Corrector Power Supply Controller). Besides general control, monitor and configuration, the fast correctors will be also applied for the fast orbit feedback. The CPSC with EPICS IOC is therefore dedicatedly designed and the embedded FPGA will handle fast update application. Synchronization mechanism and built-in waveform are also supported. Fig. 1 shows the overall control of power supplies for each cell of the storage ring.

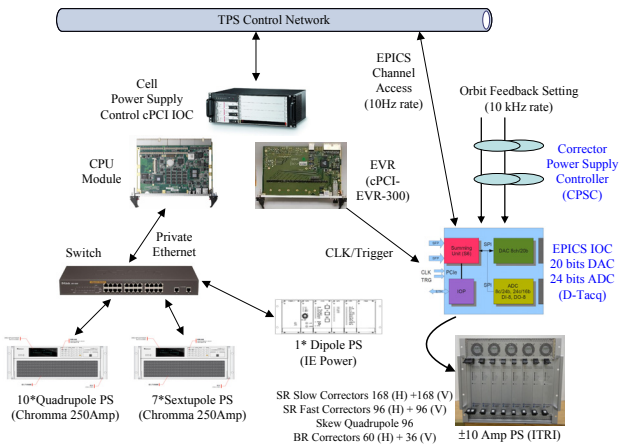

Figure 1: Control infrastructure in one cell of TPS storage ring power supplies.

Figure 2: Corrector power supply crate. There will be 8 power supply modules in one crate and the most left slot will be plugged in one CPSC.

BOOSTER SYNCHROTRON POWER SUPPLY AND ITS CONTROL

The booster power supply is composed of one 1200 Amp dipole power supply with maximum current 1200 Ampere and four quadrupole power supplies with maximum current of 120 Ampere. These power supplies will be equipped with the same controller with serial control interface internally. Serial to Ethernet adapter will interface with control system. These power supplies can accept external waveform reference input or generate waveform by internal waveform generator. All power supply can be operated at 3 Hz. The most probably drive waveform is sinusoidal wave.

POWER SUPPLY FOR TRANSPORT LINES AND ITS CONTROL

Power supplies for the linac to the booster transport line and booster to the storage ring power supply consists of dipole and quadrupole power supplies. Since the rating of the power supply is 250 Amp only, to meet the requirement of dipole magnet, it needs parallel up to three sets. The power supplies have the same Ethernet interface with the storage ring sextupole. The corrector power supply will be controlled by the CPSC module also.

There are two DC septa in the booster extraction and storage ring injection. The same power supply will be used for this application.

VIRTUAL POWER SUPPLY CONTROL ENVIRONMENT

The virtual power supply control environment is established to develop the operation progress of TPS magnet power supply. The dedicated soft-IOCs are built individually at the 24 cPCI platforms to operate the devices of the 24 cells of storage ring respectively. Each soft-IOC is used to control 10 quadrupole magnet power supplies and 7 sextupole magnet power supplies, and one of soft-IOC is appended to control only one dipole magnet power supply.

To create the EPICS support for virtual power supply control environment, each soft-IOC is set up with the specific EPICS base, modules and extensions at the Linux operation system. The related software environment is summarized as shown in Table 2.

Table 2: Software Environment of the EPICS Support

	Version
OS	IOC: Fedora Core 11 (2.6.29) Client: RHEL 5 (2.6.18)
EPICS	base-3.14.10
Modules	calc-2.6.7 seq-2.0.12
Extension	edm-1.12.xx labCA-3.1

To control and monitor power supplies based on EPICS environment via Ethernet, the clients should be installed the specific EPICS base and the graphical OPI (Operation Interface) toolkits, such as EDM (Extensible Display Manager) [7] and MATLAB (channel access via the labCA module [8]) for EPICS channel access.

At the database layer of soft-IOC, the DTYP (Device Type) field of records was set to be the "Soft Channel" mechanism for simulating the corresponded setting and reading data of power supplies. The signal noise was also generated to add for simulating actual current status for developing high level application programs.

OPERATION INTERFACE

The EDM toolkit was chosen to develop the operation interface. The client console can use the specific EDM page to access the data via PV channel access. The preliminary GUI page of storage ring dipole, quadrupole and sextupole power supplies controls as shown in Fig. 3. Fig. 4 shows the GUI page of storage ring vertical corrector, horizontal corrector and skew quadrupole power supplies controls. The macro name method was regularly used to switch each display page. The main control page was shown critical information for observing status easily, and the main operation process functions are also executed from the panel.

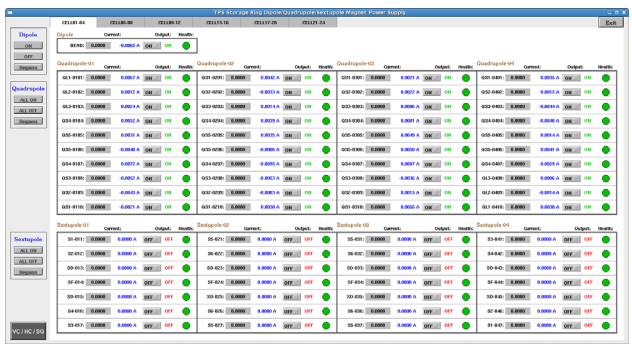

Figure 3: The operation interface of storage ring dipole, quadrupole and sextupole power supplies.

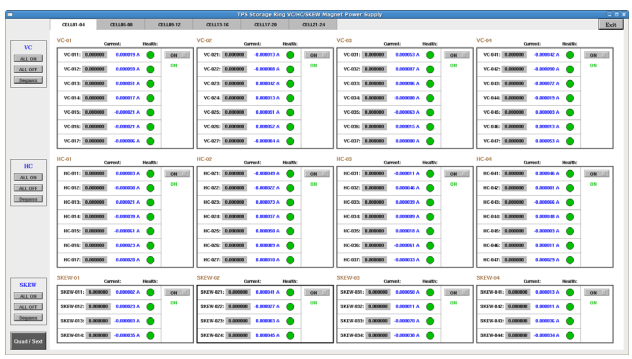

Figure 4: The operation interface of storage ring vertical corrector, horizontal corrector and skew quadrupole power supplies.

The MATLAB toolkit with labCA is adopted to develop the high level application program for commissioning and diverse operational procedures. The application includes the specific overall power on/off control, degauss process, checking power supply status, operation performance analysis, operation statistics and etc. The various operation processes will be developed and tested according to the various operation modes. The detail control page of power supplies has the trend plot for observing. Fig. 5 shows the current variation during the degauss process executed. The degauss application is also developed with the specific function of batch process to reduce the peak of power consumption for saving energy.

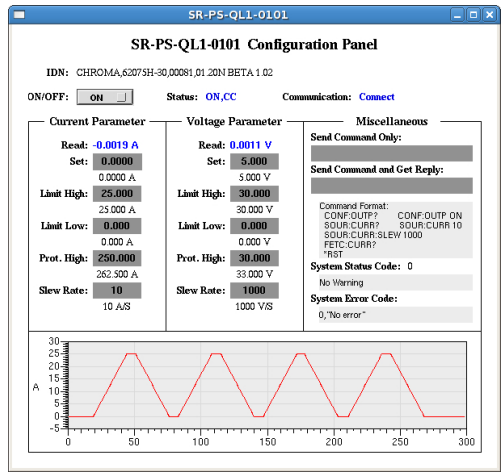

Figure 5: The current trend is shown at configure page of a quadrupole power supply during the simulated degauss process.

CURRENT STATUS

Power supply system is still in the acquisition phase. Most of power supplies will arrive in 2012. Preparation of the power supply control interface is on going. Prototyping of EPICS support for quadrupole and power supply for the storage ring and quadrupole and dipole power supplies for the transport line are in proceeding. Plan of the power supply control for the booster power supply is on the way. The CPSC module was contracted to the vendor, detailed design is in proceeding. Preliminary user interface and operation supports are addressed in this report.

REFERENCES

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